ULLETIN 472
PRIL 1962

GROWING CHRISTMAS TREES FROM SEED

ST VIRGINIA UNIVERSITY AGRICULTURAL EXPERIMENT STATION

THE AUTHORS

Authors of *Growing Christmas Trees from Seed* are E. H. Tryon, Silviculturist in the Agricultural Experiment Station and Professor of Silviculture in the Division of Forestry, and H. G. Woodrum, Superintendent of State Forest Tree Nursery, Lakin, West Virginia.

West Virginia University
Agricultural Experiment Station
College of Agriculture, Forestry, and Home Economics
A. H. VanLandingham, Director
Morgantown

Growing Christmas Trees from Seed

E. H. TRYON and H. G. WOODRUM

Introduction

PINES, spruces, and firs which are suitable for Christmas trees may be raised from seed by the Christmas tree grower. The home production of trees from seed requires a great deal more work and time than simply ordering and handling seedlings from a state or commercial nursery. However, there are advantages for the grower who has his own nursery seedbeds. Certain preferred Christmas tree species, not always readily available from nurseries, may be produced in these seedbeds. Home production also assures the grower that his trees will be available for planting at his convenience.

Tree seedlings can be raised from seed by methods quite like those used in gardening. The selection of the seedbed site where the Christmas tree seedlings are to be grown is the first step to be undertaken, and also one of the most important. The selection of a poor site will increase the difficulty of raising the stock, and could result in failure of the project.

Selection of Nursery Site

When selecting a nursery site for seedbeds, careful consideration should be given to the five following conditions:

1. The soil should be light in texture, preferably a sandy loam. Never choose a heavy clay soil, as the roots of the seedlings are subject to injury when the seedlings are lifted from the seedbed. A heavy soil may crust on the surface when dry and delay germination, and seedlings growing in such soil are more subject to disease and frost heaving. Also, a heavy soil often remains wet in the spring, delaying regular nursery operations.

2. The soil should be reasonably fertile, but should not be high in lime. A pH of 5.0 to 6.0 is preferred for Christmas tree species. It is unlikely that the soil pH will be too low, although it may be somewhat below pH 5.0 and still be suitable. However, soils which have been limed, especially within the last year or two, may have a pH above 6.5 and should not be used. This higher pH may cause yellowing of the foliage and reduce growth. It also favors a disease called "damping-off." It is a good idea to play safe, regardless of the past treatment of the area, and

send a soil sample to the West Virginia University Agricultural Experiment Station in Morgantown to be tested. Contact your County Agricultural Agent for instructions in collecting and shipping the soil sample.

3. The ground should slope slightly, as both good water and air drainage are necessary.

4. A water supply must be nearby, as the seedbeds require watering during dry periods from the time the seeds are sown until the seedlings are removed.

5. If possible, avoid areas where frequent frosts are known to occur. Unfortunately, the better sites for a nursery may be in a frost area.

Seed Source

Seed for the production of Christmas tree seedlings may be obtained from commercial seed dealers or from cones carefully selected, collected, and processed by the grower. Seedlings grown from local native seed are well adapted climatically to local growing conditions. However, the grower will probably elect to purchase seed from reputable commercial dealers[1] in order to eliminate a great deal of time and labor. Such seed, usually of good

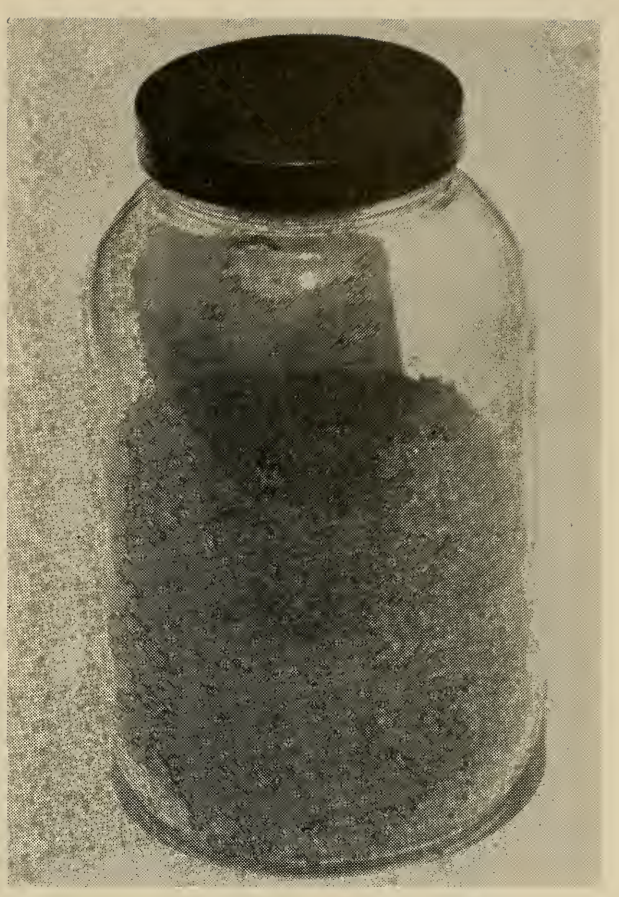
[1]See Appendix B.

SEEDBEDS in a small home nursery in Randolph County, West Virginia. In the seedbed at the left may be seen the end of a Norway spruce unit adjoining a Scotch pine unit. The water line standing by the beds at the right (arrow) supplies water for the seedbeds. Seedlings, which will grow into Christmas trees, have been planted on the hillsides.

quality and with a known germination capacity, may be purchased in small quantities, even as small as one ounce. Seed to be sown in the spring should be ordered during the preceding fall, possibly in October or November. When ordering the seed, it is suggested that for each seedlot the following information be requested: (a) kind and variety of seed, (b) percentage of germination, (c) purity, and (d) locality, including elevation, where the seed was collected.

Seed Storage

The seed, regardless of source, should be stored properly until sown in the seedbed. As soon as the seed is obtained it should be dried before storing. This operation is especially important if the seed has been collected locally rather than purchased from a commercial dealer. To dry, merely spread the seed out in a pan or tray in the sun or in a warm room. **Do not dry in an oven.** Next, the seed should be stored under dry, cold conditions. It should be placed in a jar or tin with a tight cover and stored in a cold place, preferably at a temperature between 34° and 38° F. Small lots of seed may be put in an airtight jar, such as a Mason jar, and placed in a refrigerator. Stored in this manner, seed of some of the species may remain



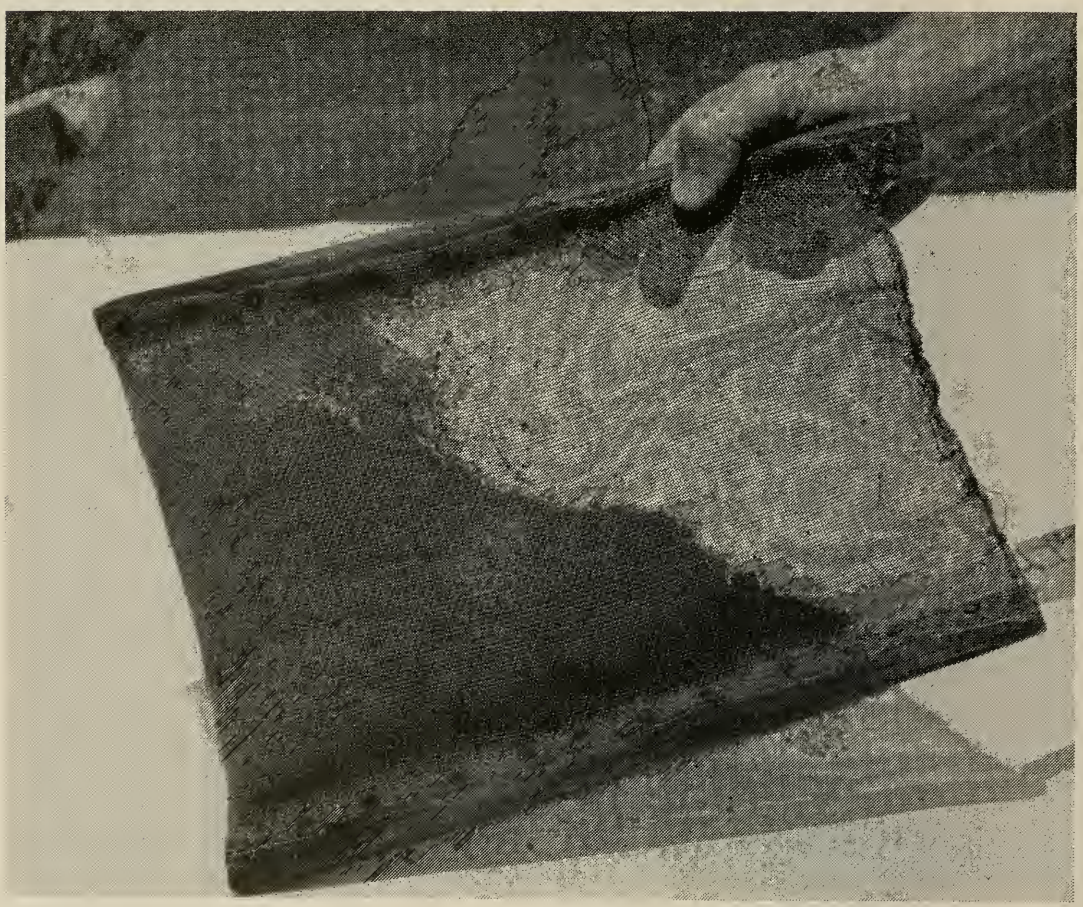
DRY, cold storage of small lots of tree seed may be accomplished by placing the seed in a jar with a tight lid. The tag contains the species name and other information on the seedlot in the jar. Store in a refrigerator until needed. For best results do not store longer than one year.

sound for several years. However, it is recommended that the storage period be only until the seed is sown in the spring or until it is to be stratified.

Seed of Austrian pine, Scotch pine, and Douglas-fir may be kept under dry, cold conditions until sown in the spring, without prior stratification, if seeded early.

The seed of balsam fir, Fraser fir, and concolor fir, however, will not be ready to germinate

when removed from storage because of a condition of embryo dormancy. In order to break this embryo dormancy, balsam and concolor fir seed should be stratified at least three months prior to sowing, and Fraser fir seed six weeks prior to sowing. Stratification can be accomplished by putting the seed in a narrow plastic screen bag and placing this bag in slightly moist peat with a temperature near 38° F. for the required period. The moisture content is satisfactory when only a drop or two of water can be squeezed from a handful of the peat. Also, stratification may be accomplished by placing the seed in a plastic screen bag in an outdoor pit dug one or two feet deep in a light-textured, well-drained soil. The seed should be put in the pit during the fall or early winter, covered to ground level, and left until needed the following spring. However, the seed tends to heat up towards the end of the period of stratification and should be carefully watched.



SEEDS of certain species, such as the firs, require stratification before they can germinate. To stratify, put the seed in a bag of plastic screening and close the bag by lacing it with flexible wire. Then place the bag in cold, moist peat. Germination of all the species listed is hastened by proper stratification.

If heating starts, the seed should be removed from the peat, stirred, and allowed to cool in a cold room (usually 18 to 48 hours), and then returned to stratification until needed. Continued heating may require that this cooling process be repeated.

Seed of white pine, red pine, and the spruces will give better and quicker germination results if they are stratified approximately six weeks prior to sowing in the spring.

When stratification is required, and facilities are not available, the seed may be sown in seedbeds in the fall instead of stratifying before spring sowing. Every effort should be made to protect fall-sown seed from rodents.

With proper stratification, germination will be hastened for all species. This will help to reduce some of the seedling problems involved with germination such as: damping-off disease, erratic germination of seed, bird damage, damage from extreme weather conditions, and the seed becoming dormant again as a result of drying out.

Seedbed Preparation

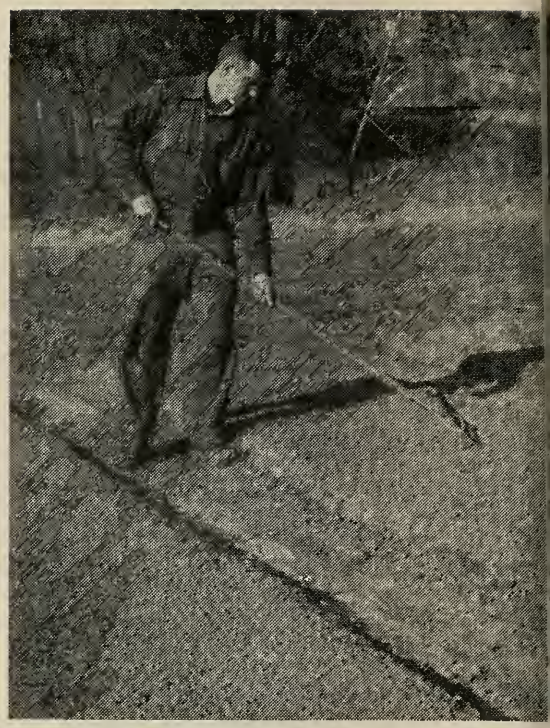
The seedbeds should be prepared just before sowing the seed. This may be either in the spring or fall, although spring seedings, especially for the pines and spruces, are recommended as being safer.

Spring sowing should be done as soon as the soil has dried out enough to be worked, usually in April, although some years it may be earlier. In other years weather conditions may not be favorable for sowing until the early part of June. These dates will vary with altitude and latitude. Fall sowing may be done as the seed is collected. Balsam fir, concolor fir, Fraser fir, and white pine may be seeded in the fall in order to avoid stratification.

The first step in the preparation of the seedbeds is to plow and disc the soil. Then lay out the seedbeds and paths using twine to mark the seedbed boundaries. Seedbeds are usually four feet wide. Their lengths depend upon the size and shape of the nursery area, as well as on the number of seedlings to be raised. Paths 18 to 24 inches wide should be made between the seedbeds.

Usually the surfaces of the seedbeds should be higher than the paths. The height is dependent upon the texture of the soil. For a heavy soil, raise the beds about 6 inches when forming them. This will allow them to settle back to give a 4-inch rise. For a light-textured soil that is well drained, a rise of 2 inches is suggested. On some sandy, droughty soils the beds need not be raised. The beds may be raised by shoveling soil from the paths into them, carefully form-

SEEDBEDS are raised by shoveling the soil from the paths into the seedbed area. Usually the seedbeds are four feet wide with a two-foot-wide path between them.



THE SEEDBEDS are raked after being formed. Large objects such as stones and clumps of sod are removed, and the surface of the bed is smoothed.

ing their edges at the same time, or by using a garden tractor with appropriate attachments. Next, the soil in the seedbeds should be carefully raked, removing all stone, sod, and other coarse material; then leveled and rolled or firmed until the surface is free of small depressions. In small beds the soil may be firmed by using a wide board and applying weight by stepping on the board. Repeat the operation until the entire bed has been firmed.

Seeding Rates

The seedbeds are now ready to be sown. The quantity of seed to sow must be determined. This amount depends upon such factors as the quality (germinability) and size of the seed, growth rate of the seedling, and fertility of the soil. For a general guide to determine the amount of seed to sow, consult Table 1.

Both the number of seeds per ounce and the percentage of sound seed will vary among different seedlots of the same species. When an accurate job of seeding is desired, the number of seeds per ounce and the percentage of sound seed should be determined.

To determine the number of seeds per ounce, first select sev-

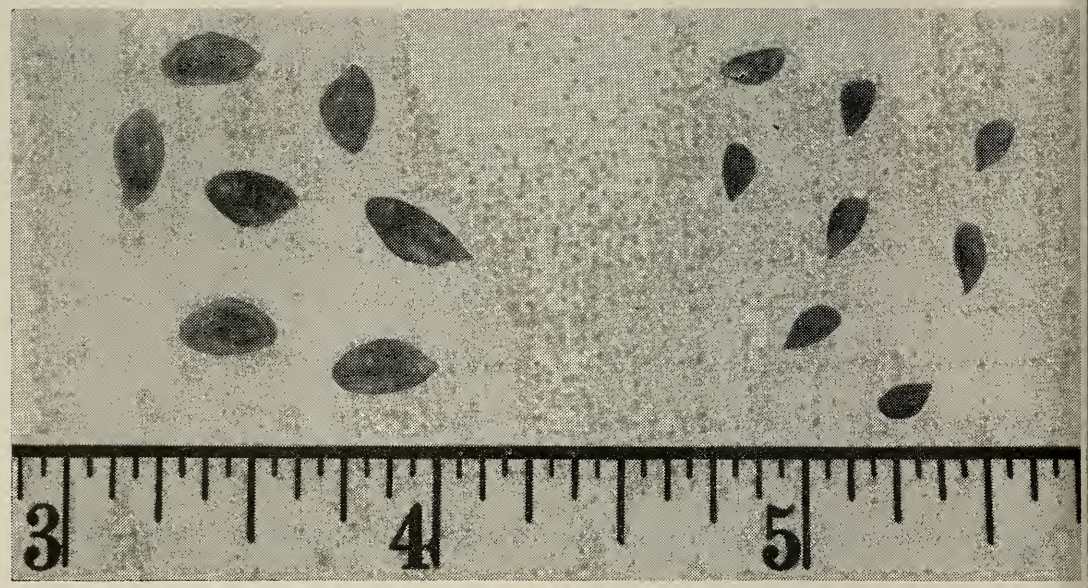
TABLE 1. APPROXIMATE AMOUNT OF SEED TO SOW IN 100 SQUARE FEET OF SEEDBED

Species	Recommended Age to Lift Seedling from Seedbed (yrs.)	Recommended Number of Seedlings to Raise Per Square Foot by Second Year	Average Number of Seeds Per Ounce	Average Germination Percentage	Amount of Seed for 100 Square Feet (Ounces)
Balsam fir (**Abies balsamea**)	4	50	3,750	20	20
Concolor fir (**Abies concolor**)	3	40	940	35*	24
Fraser fir (**Abies fraseri**)	3	50	3,120	40	14
Douglas-fir Mountain form (**Pseudotsuga taxifolia**)	3	50	2,620	80	12
Austrian pine (**Pinus nigra**)	2	40	1,560	60	10
Red pine (**Pinus resinosa**)	3	40	3,120	70	6
Scotch pine (**Pinus sylvestris**)	2 or 3	40	4,870	60	4
White pine (**Pinus strobus**)	3	40	1,560	70	8
Blue spruce (**Picea pungens**)	4	50	6,250	70*	3
Norway spruce (**Picea abies**)	3	50	3,750	70	6
Serbian spruce (**Picea omorika**)	3 or 4	50	11,500	85*	4

*Based on limited experience.

eral samples of seeds in a ran-dom manner from the seedlot. Each sample should contain from 500 to 1,000 seeds. Then count the seeds, weigh them, and cal-culate the number of seeds in an ounce.

The percentage of sound seed (germination percentage) may be obtained from information sup-plied by the seed dealer or by actually making a germination test. This test may be made by sowing the sample of each seed-

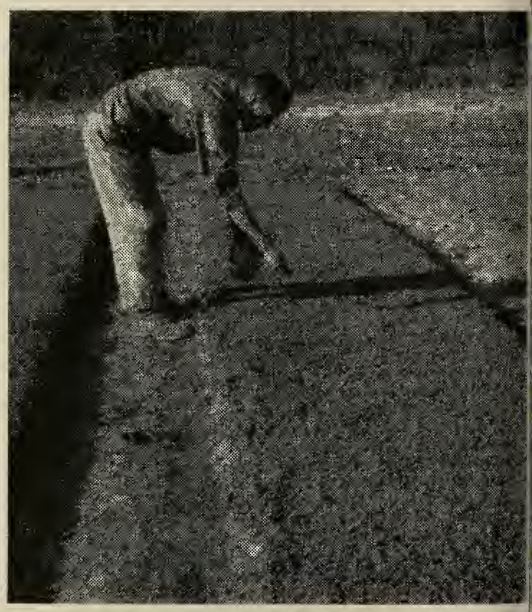


TREE SEEDS. Left. Seeds from a white pine seedlot—1,560 seeds per ounce. Right. Seeds from a Norway spruce seedlot—3,900 seeds per ounce.

lot in a well-drained sand flat, and counting the seedlings as the seeds germinate. The sand flat should be kept moist and warm, at approximately room temperature. Preferably the flat should be placed by a window while the test is being run, since low light intensities reduce the germination of some species. The tests should be made only after stratification for species requiring such treatment.

With this information, adjustments may be made to correct the seedling rates given in Table 1. Where greater accuracy is desired, the method presented in Appendix A, "Amount of Seed to Sow in Seedbed," should be used.

Permanent records of seeding rates, germination values, and amount of stock raised should be kept. These may be used as a future guide by which to produce the proper density of stock in the seedbeds.



THE BEDS are sown by scattering the seed as evenly as possible on the surface. The container holds a measured amount of seed to sow a unit of seedbed area, for example, 100 square feet. Then press the seed into the soil, and cover with one-fourth inch of sand or a sandy soil.

Method of Seeding

The seed is scattered by hand as evenly as possible over the surface of the bed and pressed into the soil. It is recommended that 100-square-foot working units be used. Next, cover the seed with sand or a sandy soil to a depth of one-fourth of an inch. Then mulch with rye or wheat straw, or cover the bed with burlap in order to keep the surface moist until the seed starts to germinate. Small wooden strips placed on top of the mulch will keep the wind from blowing it off.

Care of Seedbeds During First Growing Season

Water: As soon as the seedbed is sown, covered, and mulched, it must be watered. The bed must be kept moist but not wet. Watering is generally required throughout the summer and often is done in the evening when lower temperatures will keep evaporational loss at a minimum. However, watering may be done at any time without harm to the stock. A lawn-type sprinkler will do the job efficiently; however, a portable power unit may be needed for watering large seedbed areas.

Water may also be needed to protect the new growth on seedlings from damage by spring frosts. When a frost occurs apply about one-quarter inch of water just before sunrise to protect the plants from frost injury.

Also, high soil temperatures will harm succulent, young seedlings. Such high soil temperatures may be lowered by watering during the day.

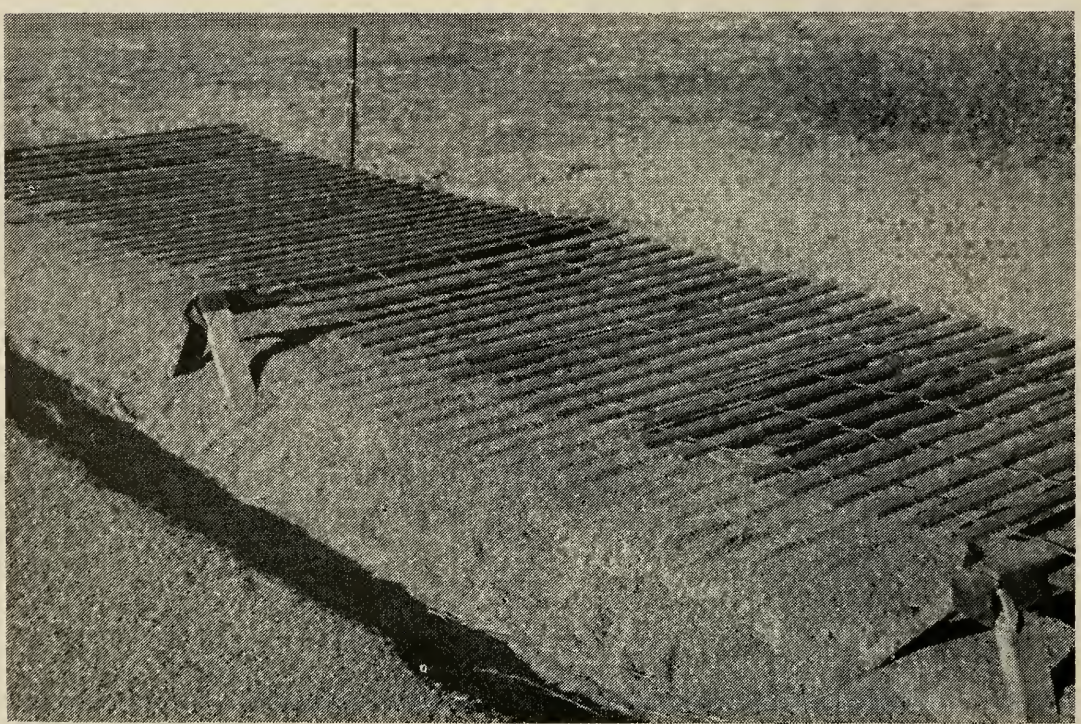
Removal of Mulch: The mulch used to cover the seedbeds at the time of seeding should be carefully removed when it is determined that the majority of viable seed have germinated. Removing

MULCH the seedbeds with straw 4 to 6 inches deep as soon as the seed has been sown and covered. Place wooden strips on top of the straw to hold it in place.

the mulch too soon may result in surface drying of the seedbed and a reduction in germination. If the mulch is left on the seedbeds too long, many of the seeds which germinate early will produce long spindly seedlings. Such seedlings are especially susceptible to damage.

Sometimes it is necessary to put the mulch back on the beds to protect the seedlings from adverse weather conditions. Therefore consideration should be given to placement when the mulch is removed.

Shade: Seedlings may need to be protected from heat during the first growing season. This is especially true of the firs and spruces. The pines probably will do satisfactorily without such protection. As soon as the mulch is removed from the beds, shade should be added when needed. About 50 per cent shade should be provided. Shade frames may be constructed of laths spaced about 1½ inches apart, similar to snow fence, or plastic screening may be used. The shade frame should be about one foot above the surface of the bed. Shade should be removed during damp weather and following heavy rains to allow the evaporation of excessive amounts of moisture with improved air cir-



SHADE is recommended for some of the more tender species during germination and much of the first growing season. Snow fence, slats, or screening which allow about 50 per cent of the light to reach the seedbed are commonly used. The shading material should be placed about 12 inches above the surface of the seedbed.

culation. This will tend to reduce disease incidence.

Birds: Birds may do considerable damage to the seedlings soon after germination. Where such damage is heavy, some type of protection must be used. Screens, bird watchers, and repellents may be used to protect seedlings from birds. For the small nursery, screens are believed to be the most practical. Plastic screening could be put to a combined use by protecting the seedlings from birds and providing necessary shade.

Weeds: Prompt removal of weeds from the bed is very important. The first weeding should be made about two weeks after germination starts. If weeds are allowed to grow, they will smother small trees. The removal of weeds that have large root systems will damage the seedlings. Weeding may be done by hand. A light application of sawdust may be applied to the surface immediately after weeding. Weeds also may be controlled by the application of chemical fumigants to the soil before the seed is sown. Such fumigants[2] include methyl bromide, Vapam, and Mylone. Directions for use are usually on the container. **Caution must be exercised in the use of all chemical fumigants.**

Seedling Density: The proper density of seedlings, or number of seedlings per square foot of seedbed area, should be maintained in order to produce strong healthy stock. The suggested density for two-year-old seedlings of the Christmas tree species is presented in Table 1.

The proper density will vary with species and age and size of stock when lifted. Species that make rapid growth (pines) should be grown less densely than those that grow slowly (most spruces and firs). The longer the stock stays in the seedbeds the less the density should be.

When the seedlings are crowded in the seedbed they become weak, spindly, and subject to increased disease damage. Such seedlings, when field planted, give poor results. Sparsely-stocked seedbeds will produce good stock. However, in such beds the production cost is increased as a result of wasted space and an increased weed problem. Most persons raising tree seedlings for the first time tend to produce overstocked beds. This condition is better than understocking as it may be corrected by thinning the excess stock during the first growing season.

Hardening stock: The seedlings should harden sufficiently by fall to prevent killing by low temperatures. This is done during the latter part of the summer by gradually reducing the amount of

[2]See Appendix B.

water, and shade, if it is used. Late applications of nitrate fertilizer are not recommended because they tend to keep the plants succulent.

Soil Improvement and Fertilization

A light-textured soil such as a sandy loam is desirable for a tree seedling nursery, as mentioned under "Selection of Nursery Site." In general, heavy soils such as clay should not be used. However, a person wishing to raise tree seedlings on a small scale but who has only a heavy soil available may use such soil if he improves it. Additions of organic matter such as fresh sawdust or peat which decompose slowly will improve the drainage and workability of that soil. Sawdust, 2 to 4 inches deep, should be spread on the surface of the seedbed, and then worked into the soil. Additional nitrate fertilizer will be needed if sawdust is added. Sandy soils, having excessive drainage, are rare in West Virginia in areas suitable for the location of a nursery, but the addition of the same types of organic matter will improve the moisture properties of these soils.

Most soils should be fairly close to the preferred pH range of 5.0 to 6.0 for the Christmas tree species. However, a soil limed recently may have too high a pH. A high pH may be lowered by the addition of such chemicals as sulphur or ferrous sulphate, or by the use of an acid-forming fertilizer such as ammonium sulphate.

Liming the soil, a common practice in agriculture, is not recommended generally for Christmas tree species because it may favor the serious damping-off disease.

The continuous production of tree seedlings in a nursery places a heavy drain on the soil nutrients. Fertilizing is necessary, or soon will be, for any soil in which seedlings are to be raised year after year. The type and amount of fertilizer to use will depend upon the soil, its past treatment, and the species raised. No definite recommendation can be made which would be suitable for all nurseries. In most instances, the fertility program of a forest nursery has developed from years of experience in raising certain tree species in a certain soil.

The following program of fertilizing is suggested for seedbed areas where a specific program has not been developed:

(a) Apply 8 ounces of 5-10-10 fertilizer to 100 square feet of seedbed area when the beds are formed.

(b) Make one application of pelleted ammonium nitrate (33% N) at the rate of 8

ounces to 100 square feet of seedbed area about six weeks after the seed has germinated.

(c) Follow the nitrate application with 12 ounces of 0-20-20, a powder, for each 100 square feet of nursery beds.

(d) Be sure to knock the fertilizer off the plants immediately after application so that the foliage will not be burned.

If sawdust has been used to improve the soil, an additional 16 ounces of ammonium nitrate should be added to each 100 square feet when the beds are formed.

With experience and soil tests, the fertilizer rates for any nursery soil will no doubt need revision.

Diseases

Diseases caused by fungi and nematodes may harm seedlings in the seedbeds. A fungus disease called "damping-off" often kills seedlings immediately after germination of the seed, and may persist for several days. The disease may be recognized by a watery constriction of the stem at the ground line and a toppling over of the seedling. Older seedlings may be killed by fungi which cause root rot or as a result of damage caused by nematodes (microscopic parasitic worms). Certain chemicals may be applied to the soil of the seedbed to control such troubles. However, **do not apply chemicals to the soil until it is known that the trouble is present.** These chemicals, when applied, should not always be expected to give 100 per cent control. However, they do help to reduce the intensity of the trouble even when the disease is severe.

The chemical fumigants, methyl bromide, Vapam, and Mylone, suggested for control of weeds, also are effective in controlling soil fungi and nematodes.

Care of Seedlings After First Growing Season

The seedbeds should be mulched at the end of the first growing season in the latter part of November or early December to protect the seedlings from low winter temperatures, and to reduce frost heaving of the young seedlings. Good wheat or rye straw are suitable materials for mulching. Apply the straw 4 or 5 inches thick directly on top of the seedlings in the seedbeds. The straw should be held in place with light, wooden slats to keep it from being blown away by the wind.

To reduce frost heaving, a thin layer of sawdust, about one-quarter inch, may be applied to

the surface of the seedbed early in the fall, prior to covering with straw. Should the soil from the edges of the raised beds tend to wash into the paths, fill the paths about one-half the height of the beds with the mulch.

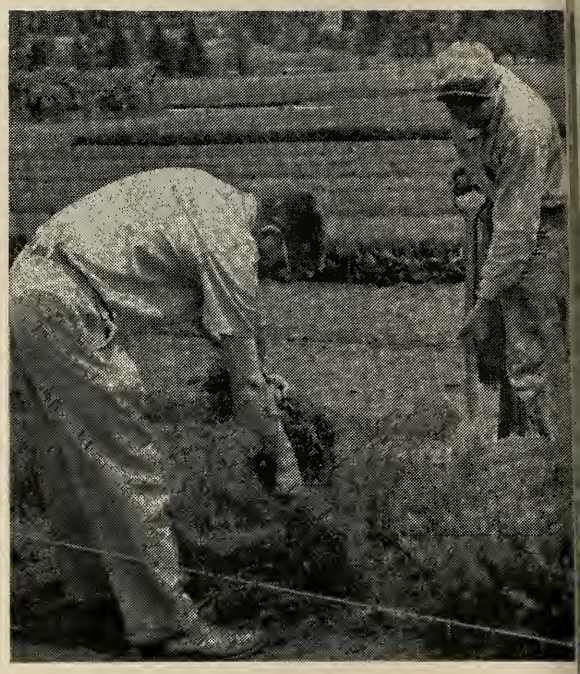
As soon as the weather warms up in the spring after the usual period of freezing and thawing, the straw should be removed. The swelling of the buds or start of growth of the seedlings is a good indicator of the time to remove the straw.

After the straw is removed and when new growth is evident, care should be taken that the seedlings are not damaged by frosts. If a frost does occur, water the seedlings early in the morning before the sun rises. A straw mulch will also offer protection if put on the beds before the frost settles.

An application of granulated 5-10-10 or 10-10-10 fertilizer is recommended at the rate of one-half pound per 100 square feet after the mulch is removed in the spring. When applying the fertilizer, care should be taken that the foliage is not burned. Knock the fertilizer off the foliage, and water it into the soil.

Lifting Seedlings

The seedlings are lifted from the beds when they are large enough for planting in the Christmas tree plantation or for transplanting. The length of time that seedlings remain in the seedbed depends upon such factors as rate of growth and soil fertility. Generally the pines listed should remain in the seedbed two years, and the other species three or even four years. Stock may be lifted by loosening the soil around the roots of the seedling with a spade or fork, then pulling the seedlings out by hand.



A TWO-MAN team is suggested for lifting the seedlings from the seedbed. One man loosens the seedlings with a spade while the other carefully pulls them from the loosened spot in the bed as shown here.

In transplanting, the seedlings are moved to another portion of the nursery so that each plant has more room to grow. This results in a plant with a more compact root system than the root

system of a plant left in the seedbed the same total number of years. The plants stay in the transplant beds usually for one or two years, and then are set out in the Christmas tree plantation. Various spacings between trees are used in transplanting. For Christmas trees, it is recommended that the spruces and firs be set 4 inches apart, and the pines 5 inches apart. This is a somewhat wider spacing than is recommended for transplanting forest trees. However, it is believed that this wider spacing is justified in raising Christmas trees because the individual plant is more valuable than a forest tree plant and its branch development is so important. Transplants should not require watering, and may be moved from the seedbed either in the fall or the spring.

For more detailed information on the subject of growing Christmas trees from seed, consult the three publications listed under "Reference Material" in Appendix B.

One item of considerable importance in raising tree seedlings and transplants is **care**. If you are not in a position to look after the seedlings, especially during the first year, don't try to raise them; purchase them from a nursery.

Cautions

1. **Do not attempt to raise balsam fir in the warmer areas of West Virginia.**
2. **For the first attempt, try raising pines. They may be grown with less difficulty than the firs and spruces.**
3. **If seedlings are to be raised for several years, rotate the seedbed areas.**
4. **Do not use chemicals for weed and disease control unless they are needed.**
5. **Observe safety precautions when using soil fumigants.**
6. **Too little fertilization is better than too much.**
7. **Avoid too dense stocking in seedbeds.**
8. **Do not underestimate the importance of proper seed stratification.**
9. **Know the quality (germinability) of the seed you are to sow.**
10. **Failures are sure to occur, but they can be reduced by constant care.**

APPENDIX A

Amount of Seed to Sow in Seedbed

The amount of seed to use in broadcast-sown nursery beds may be computed by a formula, provided adequate information on the seedlot is available.

The number of ounces of seed to sow per 100 square feet of seedbed may be estimated by using the following formula.

$$O = \frac{100 \times D}{N \times G \times T}$$

When:

O = ounces of seed.

D = density, number of seedlings desired per square foot in the seedbed.

N = number of seeds per ounce, as they come from the container at the time of sowing.

G = germination percentage, the percentage of seed that will germinate (expressed as a decimal).

T = tree percentage, the percentage of sound seed that will produce plantable seedlings (expressed as a decimal).

The value 100 in the formula represents 100 square feet of seedbed area.

The density (D) must be determined before sowing the seed. For guidance in choosing the number of seedlings per square foot, consult Table 1 and the section on "Seedling Density," page 13.

The number of seeds per ounce (N) should be determined by weighing the seed as it comes from the container just before sowing in the seedbed. A sample of 1,000 seeds is adequate. For seed stored under dry, cold conditions, the number of seeds per ounce may be used when given by the seed dealer, but must be recalculated if the seed has been stratified. Stratified seed picks up moisture and is heavier than dry seed.

The germination percentage (G) may be determined by a germination test as described on page 9. The germination percentage as listed on seedlots obtained from dealers may be used; however, it is desirable to check this value by a germination test.

The tree percentage (T) is approximated from the germination percentage based on experience in nursery practice. The lower the germination percentage, the lower will be the tree percentage. Furthermore, as the germination percentage becomes lower, the tree percentage is reduced but at a faster rate. Thus, for a germination percentage of 85 to 90, the tree percentage will be about 40 per cent; when the germination percentage is as low as 25 the tree percentage will be about 2 or 3 per cent. For the Christmas tree species listed in this Bulletin, the appropriate value indicated in the species groups below should be used in the formula.

Species Group	Tree Percentage
Pines	0.4
Spruces and Douglas-fir	0.3
Firs	0.2

The formula is used as follows:

A seedlot of white pine has 1,500 seeds per ounce, and a germination percentage of 70. Forty seedlings per square foot is the desired density. Now place these values, and the tree percentage value of 0.4 for a pine, in the formula and solve for "O", which is the number of ounces of seed to sow for 100 square feet of seedbed, as follows:

$$O = \frac{100 \times 40}{1{,}500 \times 0.7 \times 0.4}$$

$$O = 9.5$$

Thus, 9.5 ounces of the seed is needed to sow 100 square feet of seedbed.

(Turn page for Appendix B.)

APPENDIX B

Commercial Seed Dealers

There are many reliable commercial tree seed dealers in the country. Some of them are —

Forestry Associates
P. O. Box 1069
Allentown, Pennsylvania

Bertha E. Rhodes
Lock Box 96
Merrillan, Wisconsin

Richard V. Bausher
2015 Eastman Avenue
Bethlehem, Pennsylvania

F. W. Schumacher
Horticulturist
Sandwich, Massachusetts

Herbst Brothers
Seedman, Inc.
678 Broadway
New York 12, New York

S. & R. Seed Dealer's Co.
S. J. and R. J. Nesies
Cass Lake, Minnesota

Woodlot Seed Company
Norway, Michigan

Alvin L. Reichard
American Tree Seeds
Sturgeon Bay, Wisconsin

J. B. Woods
Woodseed Ltd.
Box 647
Salem, Oregon

A list of "Commercial Sources of Forest Tree Seed" may be obtained from the Forest Service, U. S. Department of Agriculture, Washington, D. C. This list will be especially useful to persons wishing to obtain seeds of the less common species.

Chemicals

Some of the chemicals listed may be obtained through farmers' feed and supply markets. Others may not be generally available and may be purchased as indicated.

Methyl Bromide

Miller Chemical Company, Charles Town, W. Va.
Dow Chemical Company, Midland, Mich.
Cabell Chemical Company, Huntington, W. Va.
Chemical Formulators, Charleston, W. Va.

Vapam

Miller Chemical Company, Charles Town, W. Va.
Stauffer Chemical Company, Chauncy, N. Y.
Cabell Chemical Company, Huntington, W. Va.
Chemical Formulators, Charleston, W. Va.

Crag Mylone

Miller Chemical Company, Charles Town, W. Va.

Reference Material

WOODY-PLANT SEED MANUAL, prepared by the Forest Service, U. S. Department of Agriculture, as Miscellaneous Publication 654, 1948, may be obtained from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

SEEDING AND PLANTING IN THE PRACTICE OF FORESTRY, by J. W. Toumey and C. F. Korstian, 1942, is published by John Wiley and Sons, Inc., New York, New York.

FOREST NURSERY PRACTICE IN THE LAKE STATES, by J. H. Stoeckeler and G. W. Jones, Forest Service, U. S. Department of Agriculture. Agricultural Handbook No. 110, 1957, may be obtained from Sperintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.